1998

Prospective Memory: The Relation of Executive Function to Aging

Joesph A. Mikels '98
Illinois Wesleyan University

Prospective Memory: The Relation of Executive Function to Aging

Joseph A. Mikels and Johnna K. Shapiro
Illinois Wesleyan University

Abstract

The executive functions of the frontal lobe seem to play an integral role in the mediation of prospective memory, as suggested by the results of recent studies (Shallice & Burgess, 1991; Cockburn, 1995; Shapiro, Shapiro, Alper, & Russell, in press). In the present study two groups were examined in terms of their performance on four different prospective memory tasks. The two groups included younger adults (ages 18-21) and older adults (ages 62-80). Both groups were asked to perform each of four prospective memory tasks (an event-based, disembedded task; an event-based, embedded task; a time-based, disembedded task; and a time-based, embedded task) webbed within a general knowledge quiz. The participants also were tested using the Stroop Test and the Wisconsin Card Sort Task, which have been acknowledged as predictors of frontal lobe dysfunction. The Kaufmann Brief Intelligence Test, the Williams Inhibition Test, and an Immediate Recall Test were also administered. The results indicate that both groups performed significantly poorer on the TD task in comparison to the ED task. This finding suggests that a deficit in internal cuing and attentional resources may be responsible for a PM performance deficit.

Prospective Memory: The Relation of Executive Function to Aging.

Memory as a cognitive construct consists of numerous broad concepts, which researchers and theorists use to form a comprehensive understanding of what it means to remember. The most common and general understanding of memory stems from the concept of "retrospective memory" (RM). This type of memory encompasses recall of past events or information (e.g., remembering the date of your birth). RM possesses great significance to us, yet there is another type of memory that plays a different role: "prospective memory" (PM), which requires recall of an intention for performing a specific action in the future. The process of remembering to take medication epitomizes this construct; for many people (for instance, individuals with heart problems) taking medication is woven in their daily routines. Failure to remember to take medicine can often lead to serious medical complications. This example as well as many others (e.g., remembering to go to an appointment, remembering to pick up a child at a specific time from school, etc.) demonstrate the significance of such remembering. There has been surprisingly little research on prospective memory, possibly due to theoretical problems in defining it (Searleman & Herrmann, 1994).

Even though the number of studies is small the foci of existing research on prospective memory is still quite diverse; these foci include concentration on differentiating PM from RM, examination of prospective memory-specific factors (internal versus external cuing, time-based versus event-based tasks, and embedded versus disembedded designs), specific research designs (in-lab versus outside of lab, natural versus artificial tasks), comparison of PM performance in younger and older adults, and, finally, examination of PM performance in brain injured groups. Yet even with such a diverse arena, the underlying issue is the distinction between PM and RM, or possible lack thereof.

Prospective Memory as Different from Retrospective Memory

Searleman and Herrmann (1994) define prospective memory as a memory set in a future time frame, one way to differentiate PM from RM. The latter contains information from a past time frame, whereas the former involves remembering to execute an action in a future time frame. The essential question this discussion gives rise to is whether there are different mechanisms for PM and RM.

Distinguishing between the two forms of memory is often a difficult and controversial endeavor. Crowder (1995) argues that PM and RM originate from the same mechanism, namely RM. He argues that all memory is inherently retrospective whereas all intentions for actions in the future are necessarily prospective. Based on this stringent criteria, Crowder suggests the term PM is misleading; an intention and memory are two theoretically different concepts. He claims that "prospective memory" consists of a retrospective memory for an action; PM is either an intention or a retrospective memory, but it cannot be both.

The essential problem to this argument revolves around the execution of the action as being *intended*. In order for the intended action to be performed there must necessarily be a mechanism by which the specific memory of the need to act can be recalled at a specific time. Crowder (1995) fails to recognize that a memory of intention is encoded in a time-specific frame to be executed in the future. The action cannot occur independently of the specific memory. There is an intrinsic connection; and furthermore, the memory is encoded with a specific cue for retrieval. Cockburn (1995) counters Crowder's (1995) argument by focusing on this retrieval cue.

According to Cockburn (1995), in order to recall the specific action that is to be performed, there must be a cue exhibiting an executive influence as to specifically *when* the memory is to be recalled. Executive functions include abilities such as planning, impulse control, working memory, and attentional control (Roberts & Pennington, 1996). PM then, might rely on planning and attention. If the action is to be carried out in the near future, one may only need to focus immediate attention on the retrieval cue for performing the action. Yet if the task is farther into the future, performance then necessitates planning the specific cues and measures that must occur prior to the action (Neisser, 1982). The crucial aspect, therefore, in differentiating PM from RM might be PM's reliance on executive functioning.

Factors Significant in Prospective Remembering

Using this distinction, there still seems to be some relation between prospective and retrospective memory. Einstein, Holland, McDaniel, and Guynn (1992) address this relation by discussing a componential analysis of PM. They divide PM into a retrospective component (the memory of what specific action is to be executed) and a prospective component (remembering to perform the action at a specific time). They differentiate PM from RM then in terms of the necessity of remembering to perform the action in addition to the recall of what the action is. The crucial factor deals with how and when the memory is recalled, relating once again to cues and executive functions.

The cues employed in retrieval can be either internal and self-initiated or external and initiated by the environment. Einstein and McDaniel (1990) described this dichotomy, addressing relevant experimental design issues. If there were indeed different mechanisms for PM and RM, one would expect to find no correlation between the two. In two experiments investigating retrospective and prospective memory, they found no reliable association between the two forms of memory tasks. The design of their PM task was event-based. Event-based tasks rely on the presentation of an external cue, rather than internal motivation and cuing. Einstein and McDaniel (1990) presented words to participants on a computer and asked the participants to hit a specific key on the keyboard every time the word "rake" appeared on the screen. As an RM measure, they instructed participants to recall all the presented words in order. The PM action, hitting the key after "rake" appeared, was externally cued by the presentation of the specific word (an event-based PM task).

Internal cues, which contain no obvious and specific external cuing, occur most often in time-based tasks (i.e., tasks that require execution of the PM action after a set period of time). For example, remembering to pick up a child after school at three o'clock or putting the laundry in the dryer in one hour relies on time-based PM with internal cuing. However, one can use an external cue as an effective PM strategy, such as writing a note as a reminder, for time-based tasks. Prospective memory actions rely upon either time-based or event-based cues.

Although one focus of past research has been the differentiation of PM from RM, the distinction is strengthened through examining specifically what qualifies as a PM task, as Cockburn (1995) has done. She suggested a further distinction with relevance for both time-based and event-based tasks. PM experiments usually consist of two task types: an ongoing, filler activity and the actual PM task(s). The relation between these two types of tasks can take one of two forms: "disembedded" or "embedded." A task that interrupts the ongoing activity (a "disembedded" task), demands that the participants switch attention from the ongoing task to the PM action. The other possibility is a PM task (an "embedded" task) which complements the ongoing activity as an extension of the task, rather than interfering. For example, signing your name in the test booklet at the end of the task.

Cockburn (1995) employed both types of prospective memory tasks (embedded and disembedded tasks) in several experiments. In one specific experiment, a digit-symbol substitution task, she asked the participant to note the start time, work for three minutes, then stop (a disembedded, time-based task), and go on to a letter cancellation exercise. Upon completion of this exercise, the participant was to write the time of completion at the bottom of the page (an embedded, event-based task). The first PM task (to stop working after three minutes) constitutes a disembedded task requiring an interruption and redirection of attention, whereas the second task (to write the time of completion) is an embedded task. The latter task is consistent with the ongoing activity, in that it required no redirection of attention. Although research has focused strictly on time-based, disembedded and event-based, embedded PM tasks, the conditions can be employed factorially. Kvavilashvili (1992) evaluated Cockburn's two PM experiments as very well constructed for testing PM, according to a critical examination of this experiment among others.

Kvavilashvili (1992) points out that many previous prospective memory studies were conducted out of a laboratory in natural settings (e.g., Dobbs & Rule, 1987; Maylor, 1990), and were therefore lacking internal validity. Conversely, several studies conducted in the laboratory lacked external validity because tasks that people would not normally perform in their daily lives and would perceive as novel were used (e.g., Einstein and McDaniel, 1990). This type of task is referred to as an artificial task, as opposed to a task that would be performed normally in daily functioning: a natural task. Kvavilashvili (1992) concluded that the ideal PM experiment would be one conducted in a laboratory with a natural task, as Cockburn's (1995) was.

Kvavilashvili (1992) draws attention to another significant factor in prospective memory research: sufficient forgetting. The experiment must be designed to allow for sufficient forgetting, to prevent a ceiling effect. Most PM tasks are rather simplistic tasks; complexity, achieved through multiple tasks, is necessary for sufficient forgetting. The best method to gain complexity might require some form of deception. If a participant *knows* that the task being tested is the execution of an intention, then s/he is not likely to "forget" in the limited time in a laboratory setting. This effect is evident in the experiment conducted by Dobbs and Rule (1987). The participants were instructed to request a red pen when a specific event occurred in the midst of another task-- without explanation as to why they were to ask for it. The participants had to repeat the directions, because no other hints would be given. Nearly 100 percent of the participants actually asked for the pen: a ceiling effect. One could conclude that the artificiality of the task was so pronounced that participants focused on that task exclusively; they completed it perfectly without any forgetting. If a natural task that allows forgetting were to be used, then the validity would increase.

Prospective Memory in Older Adults as Opposed to Younger Adults

The focus of a study by Dobbs and Rule (1987) was the relation of age to PM performance. In fact, the focus of all of the initial PM research was the examination of possible age differences in PM. Craik and Salthouse (1986) were the first to hypothesize that remembering to perform a certain action in the future would be vulnerable to aging. His speculation was founded upon common complaints from older adults that they were growing forgetful and absentminded in terms of performing certain actions in the future. Dobbs and Rule (1987) examined age differences in PM performance and found a deficit for older adults (ages 70-99) in comparison to younger adults (ages 30-65). Yet Einstein and McDaniel (1990) failed to find a similar deficit among their subjects. Their experiments were constructed to investigate both RM and PM. In their assessment of RM an effect of age was found, whereas no significant effect of age was observed for the PM test using external cuing.

Contrary to the results of Einstein and McDaniel (1990), age was related to performance on a PM task administered by Einstein, Holland, McDaniel, and Guynn (1992). The crucial difference between these contradictory results, is in the design of the experiments. Einstein, et al. (1992) employed two event-based PM tasks, which varied on the level of task complexity. The first task demanded that the participants press a key when a specific word appeared amidst other words (the "single word" condition). The second task required that the participants hit the key when any of four words appeared (the "four word" condition). They found that older and younger adults performed the "single word" task equally well, yet the older adults exhibited a significant decrease in performance on the "four word" task in comparison to the younger adults. The inability of older adults to attend to four conditions versus one demonstrates difficulties integrating and dividing attention among stimuli, therefore suggesting a deficit in executive processes.

In terms of research design, Einstein and McDaniel (1990) attributed their failure to detect an effect of age on a prospective memory task to their uncomplicated event-based design. An event-based task provides external cues, which assist greatly in prospective remembering for older adults. External cues facilitate remembering in older adults who have difficulties utilizing internal cues (Craik and Salthouse, 1986). Internal cues are most often used in time-based tasks; therefore, Einstein, McDaniel, Richardson, Guynn, and Cunifer (1995) designed a time-based task relying on internal cues to test the performance of older adults. They noted that previous experiments that failed to detect an age-related deficit on PM time-based tasks belonged to the paradigm of "out of laboratory, artificial task" (e.g., Maylor, 1990). The older adults had access to external cues, which they reported using when out of the laboratory. In order to attain results with a higher level of internal validity, Einstein et al. (1995) employed "in laboratory" experiments with a time-based PM task disembedded in a RM test. Such a design prevents older adults from using external cues. Participants were to press a key (F8) every ten minutes as they performed an oral recall word task. The PM task demonstrated an effect of age: younger adults performed the task more accurately than older adults. Einstein, et al. (1995) then conducted an experiment investigating the effect of age on an event-based task and found no effect of age. These results support the assertion that age-related deficits appear only in time-based tasks with self-initiated cues.

Einstein et al. (1995) reported yet another significant factor in their time-based prospective memory task: monitoring of time. They found that not only did older participants perform the PM task less often, but they also monitored the time less often. Since monitoring is a internal behavior of dividing attention from the ongoing task to checking the time, the results suggest that aging may disrupt executive processes utilizing attention switching in time-based tasks. Thus, high levels of time checks would indicate high levels of executive functioning, whereas lower levels of time checks would indicate the opposite.

The findings of Einstein et al. (1995) are however, not in accordance with the findings of Maylor (1993) who found an effect of age on performance of a non-complex event-based task. Participants were required to (1) write down the name of various famous male faces presented as slides and (2) to designate if they had a beard or were smoking a pipe. If the face had a beard, the participants were to circle the number of that slide. If the man in the slide was smoking a pipe, they were to put a cross through the number of that slide. For these two event-based PM tasks (denoting if the person had a beard or was smoking a pipe), an effect of age was found: young adults performed the task more effectively than the older adults. The experiment was later modified and replicated (Maylor, 1996) by increasing the number of different stimuli presented and decreasing the number of times they were presented. As predicted, the overall performance of both groups was reduced, yet a larger age-related difference did appear. This set of results is inconsistent with the initial findings of Einstein and McDaniel (1990), who did not find an age-related difference on an event-based task.

Addressing this discrepancy, Maylor (1996) pointed out that Einstein and McDaniel (1990) manipulated the difficulty of the on-going activity in order to equate younger and older participants. Older participants were presented with fewer words in the list of "to be recalled words." This design factor, Maylor (1996) implies, may be the reason no age-related deficits was detected. She also brings attention to the fact that Einstein et al.'s (1990, 1992) tasks (aside from those that were time-based) involved words. The ongoing task was to memorize a list of words and the PM task was to respond to specified words-- thus, a similar type/level of processing. The results of Maylor (1993, 1996) may have been due to her design, which involved a shift in the level of processing from semantic (face-recognition) to structural (features of the faces) levels. Maylor then theorized that older adults may have a deficiency in shifting from one level of stimulus analysis to another, as in the study by Maylor (1993), which required participants to shift attention between levels of processing (naming the face and then determining if the person had a beard or if they were smoking a pipe). This shift requires the executive functions of the frontal lobe, as both working memory and attention switching are executive processes. Such a deficit then once again constitutes a deficit in executive functioning.

It is not clear if a difference in performance is related to the level of complexity in terms of successful retrieval (Einstein et al., 1992) or a shifting from different levels of processing (Maylor, 1996). Whatever is responsible seems to require an executive function, once again supporting the differentiation of PM from RM based on PM's apparent need for executive processing.

In addition to the possibility of a PM deficit being a deficit in executive processes, it has been hypothesized that a decrease in the available amount of working memory might be responsible for an age difference. Working memory can be viewed as "the ability to maintain and manipulate short-term information needed for generating upcoming action" (Roberts & Pennington, 1996).

Working memory deficits are often found in older adults and patients with frontal lobe lesions, leading to the claim working memory is a core prefrontal process. Furthermore, there is presently general agreement that the prefrontal cortex is involved in executive functions, which are not only related to working memory, but also planning and attentional control, the other mechanisms considered to underlie deficits in PM performance.

The Frontal Lobe: Relations to Aging and Prospective Memory

More limited working memory, attentional problems, problems in shifting levels of processing, and problems with self-initiated retrieval cues are suggested as possible problems responsible for the general decrease of prospective memory functioning in older adults (Cockburn & Smith, 1994; Maylor, 1996; Einstein et al., 1995). Given that these various mechanisms constitute some of the functions of the frontal lobe, a decrease in PM task performance might be expected in individuals with deficits in frontal lobe functioning.

In support of this assertion, it has been found that the frontal lobe's neuronal count deteriorates as humans age. As determined by neuronal counting, individuals lose 15-20% of their neuronal content in the prefrontal cortex as they age. Such a decrease is observed only in specific regions and not throughout the entire brain (Cytowic, 1996). The specific deterioration of the frontal lobes in older adults, and an associated decrease in executive functioning, may be the link to lower performance on PM tasks in this population.

Shimamura (1995) explained that damage to the prefrontal cortex may impair memory performance in several different ways. He stated that a deficit in self-initiated encoding may be one of the main problematic effects from damage to the prefrontal cortex. Problems with controlling and monitoring irrelevant information surface repeatedly in patients who have sustained prefrontal injuries. One possible explanation for this type of impairment may be inadequate filtering of neural activity from the frontal lobe into posterior cortical areas. The idea that the prefrontal cortex may direct or inhibit activity in posterior cortical regions is somewhat supported by physiological evidence reported by Shimamura (1995). A deficiency in these gating or inhibitory mechanisms in the frontal lobe would qualify as a deficit in self-initiated and internal retrieval.

Shimamura, Janowsky, and Squire (1990) suggested that prospective memory is more than just a memory and an action, rather, it involves internal planning, organization, and inhibitory control mechanisms. This suggestion not only provides a more detailed differentiation between PM and RM, it also demands that executive controls be an aspect of PM, uniting PM directly to the functions of the frontal lobe. Even though such a relation is hypothesized, its only source of support comes from two case studies (Shallice & Burgess, 1991; Cockburn, 1995) and empirical research conducted by Shapiro, Shapiro, Alper, and Russell (in press).

For the clinical participants in these studies, the major difficulties arose in switching attention to a different task, while involved in an ongoing activity. After questioning the participants, it was clear that they remembered that they were to stop one activity and begin another. Theoretically, this discussion calls Einstein et al.'s (1992) componential analysis into question. The patients remembered they were to stop the initial task, signifying that the memory for the action was still intact (the retrospective component), and that the prospective component is functioning because the intention is actually recalled. Yet the participant was unable to complete the task, indicating a deficit in some PM factor. Using the term "prospective component," the possibility of a deficit in dividing attention is not adequately expressed. The memory to stop was intact and recalled, yet the behavior was not initiated. Apparently PM consists of several processes and does not simply contain a retrospective and prospective component. Therefore, the analysis of Einstein et al. (1992) must be redeveloped in specifying what mechanisms are related to PM.

Shapiro, Shapiro, Alper, and Russell (in press) conducted an examination with three groups: 24 younger adults, 20 older adults, and two individuals with frontal lobe damage. They developed an embedded event-based task and a disembedded time-based task. On both tasks the younger adults performed better than both the older adults and the frontal lobe injured patients, supporting the hypothesis that frontal lobe integrity is related to successful prospective remembering. In terms of time monitoring, the older adults demonstrated significantly fewer clock checks than younger adults. The WAIS-R information and digit-span section was also administered. The results of this testing demonstrated that retrospective encoding was still intact for the older adults (i.e., no difference was detected between younger adults, older adults, and the two patients with frontal lobe damage). In light of the computational model of PM, these results would indicate no problem in the retrospective component of PM, implying that PM impairments are fully prospective and executive in nature.

The Present Study

The present study is a modification, partial replication, and extension of the experiment conducted by Shapiro et al. (in press). An embedded, event-based task was employed, as well as a disembedded, time-based task-- similar to those used by Shapiro et al. (in press). However, an embedded, time-based task and a disembedded, event-based task were added. The event-based task employed by Shapiro et al. (in press) was modified, because it occurred only once during their experiment, at the end, whereas the time-based task occurred in three five-minute intervals. In an attempt to make the test more comparable, an event-based task was required three times in the present experiment. Extrapolated from the aforementioned studies, it was hypothesized that older adults would exhibit decreased performance on the time-based PM tasks in comparison to the younger adults, regardless of the embedded/disembedded distinction. Of all four PM tasks, it was hypothesized that the older adults would be the least accurate on the TD task (which demands both attention switching and internal cuing). Furthermore, if executive functions play an integral role in PM, PM task performance should correlate with tests of executive (frontal lobe) function (e.g., the Stoop Color Word Task, which measures the effect of interference in frontal lobe functioning). It was also hypothesized that younger adults should have a higher number of clock checks in comparison to older adults.

Method

Participants

Two separate groups were tested: 19 female and 7 male undergraduates (ages 18-21) from Illinois Wesleyan University and 12 female and 9 male older adults (ages 63-80), who are alumni of IWU. Data from seven participants were discarded due to errors in administration of the tests, misinterpretation of instructions, or changes in instructions, resulting in a final sample of 20 older adults and 20 younger adults. The mean IQ of the younger adults was 113 (SD=9.50) and that of older adults was 115 (SD=7.57). The groups did not differ on intelligence, as determined by a one-way ANOVA, $F(1, 37) = 1.01$, p=0.32. The students received extra-credit in their psychology classes for their participation, whereas the older adults were paid for their participation.

Materials

All participants received the Kaufman Brief Intelligence Test (K-BIT) which consists of three subtests: expressive vocabulary, definitions, and matrices. After screening for a base IQ, the Stroop Color Word Test and the Wisconsin Card Sort Task (WCST) were administered. These tests are established predictors of frontal lobe failure, and are considered tests of executive function. As a measure of working memory, the Immediate Recall Test was administered. In addition, all participants received the Information sub test of the Wechsler Adult Intelligence Scale- Revised (WAIS-R), which asked general knowledge questions, qualifying as a retrospective measure. The intention of administering these tests was to assess general intelligence, interference in frontal lobe functioning, flexibility in frontal lobe functioning, and working memory abilities.

The participants were administered a computer-based general knowledge quiz, which was constructed from questions by Nelson and Narens (1980). It consists of 200 trivia questions requiring one word answers. One of four PM tasks was included in this quiz.

Apparatus

A Macintosh PowerMac 8500 was used to administer the general knowledge quiz, the WIT, the Subjective Time Estimation Test, and the Immediate Recall Test. A Macintosh Powerbook 170 portable computer was used for participants unable to come to IWU.

Design and Procedure

Each participant was tested in an individual setting. The ordering of tests was determined by partial counterbalancing in a Latin square design.

There were four variations of the prospective memory task and each participant performed one of these: an event-based, embedded (EE) task, an event-based, disembedded (ED) task, a time-based, embedded (TE) task, or a time-based, disembedded (TD) task. Specific instructions varied for each subdivision, but for all the tasks, participants were instructed to type a "period" before pressing return, so that the response would be registered by the computer. For the EE task, after questions about presidents the participants were required to type an exclamation point instead of a period. Question type served as an event-based cue, and completing the task did not require that the ongoing action be interrupted (embedded). On the ED task participants were instructed to orally tell the experimenter the numbers of questions involving presidents. Once again, question type qualifies as an event-based cue, however telling the experimenter the question numbers interrupts the ongoing task (disembedded). Subjects were told that the reason for these extra tasks was to assess the functioning of our randomization program.

For the TE task were that the participants were directed to type an exclamation point after elapses of five minutes, whereas for the TD task, the participants were instructed to orally tell the experimenter the number of the question they had just completed after five minutes have passed. Since the performance of the task was after the elapse of five minutes, the tasks were both time-based, however the TE did not interrupt the ongoing task, whereas the TD did interrupt. These two additional tasks were explained to the participants as a measure of how long the test takes, since our program was "not yet fully functional." To avoid a ceiling effect and to achieve administration of a natural task that does not seem unrelated to the ongoing task, these deceptive instructions were necessary. Participants were debriefed regarding the use of this deception upon completion of all tests.

Participants receiving the TE and TD conditions were told that the time would appear on the screen when they pressed the F4 button. The experimenter pressed the key for them initially, so it was clear how the key functions. The participants had three opportunities to execute the PM task and a score out of three was then assigned. These scores were then converted into percent accuracy with 100% being performing the action three times. Clock checks were recorded, in order to compare the monitoring of time across groups.

Results

The design is quasi-experimental because the participants could not be randomly assigned to the groups. The design is a 2X4 between subjects factorial design, with one quasi-independent variable, *age group* (young and older adults), as well as one true independent variable, *task type* (the EE, ED, TE, and TD tasks, as described above). The dependent variable is percent accuracy on the PM tasks.

Percent accuracy on the PM tasks was analyzed with a two-way analysis of variance (ANOVA). No significant main effects were found for age groups, $\underline{F}(1,39) = 5.401$, $\underline{p}<.117$, but there was a significant main effect of task type, $\underline{F}(4,39) = 5.401$, $\underline{p}<.01$. Scheffe's test revealed that both age groups demonstrated significantly higher percent accuracy on the ED task ($\underline{M}$=96.6, $\underline{SD}$=10.8) in comparison to the TD task ($\underline{M}$=62.9, $\underline{SD}$=24.7). No other significant differences were determined between the task types. The ANOVA also revealed a significant interaction between test type and age group, $\underline{F}(3,39) = 3.718$, $\underline{p}<.021$ (see Table 1, attached). None of the differences between older and younger adults were significant as determined by a series of t-tests. As determined by a one-way ANOVA, the number of clock checks did not differ between older and younger adults, $\underline{F}(1,19) = .1716$, $\underline{p}<.68$.

On the tests of executive (frontal lobe) function, there were several significant differences as determined by a series of one-way ANOVAs. The older adults ($\underline{M}$=-4.1, $\underline{SD}$=9.6), as compared to the younger adults ($\underline{M}$=3.7, $\underline{SD}$=8.0), exhibited a higher level of stimulus interference on the Stroop Test, $\underline{F}(1,37) = 7.74$, $\underline{p}<.01$. The older adults ($\underline{M}$=22.1, $\underline{SD}$=16.8) also made a greater number of perseverative errors on the WCST than the younger adults ($\underline{M}$=10.7, $\underline{SD}$=11.0), $\underline{F}(1, 36) = 6.20$, $\underline{p}<.02$. There was also a significant difference on the Immediate Recall test with younger adults ($\underline{M}$=1.1, $\underline{SD}$=1.8) making fewer errors than the older adults ($\underline{M}$=2.5, $\underline{SD}$=2.0), $\underline{F}(1,39) = 5.4805$, $\underline{p}<.02$. On the WAIS-R Information subtest, older adults ($\underline{M}$=23.4, $\underline{SD}$=2.8) demonstrated significantly better recall than the younger adults ($\underline{M}$=21.2, $\underline{SD}$=2.6), $\underline{F}(1,38) = 6.7794$, $\underline{p}<0.01$.[1]

To determine the possible correlation between the executive (frontal) functions and the PM tasks, Pearson's *r* was employed. No significant correlations

[1] Since four one-way ANOVAs were used, $\underline{p}<0.0125$ should be used to determine significance. But since the present study is testing all four dimension of the PM task paradigm with such a small number of participants per dimension, significance was determined with $\underline{p}<0.05$.

were found between percent accuracy on the PM tasks and the Immediate Recall Test errors, perseverative errors on the WCST, or interference on the Stroop test (see Table 2, attached).

Discussion

Throughout the previous studies examining the effects of age on PM performance, no clear conclusion has been reached. Across the dimensions of the time/event-based distinction and the embedded/disembedded distinction, findings suggest that tests relying on internal, self-initiated cuing and attention switching often pose problems for older adults. However, neither a time-based, embedded task nor an event-based, disembedded task have been examined in previous studies. The present study was designed to examine all the dimensions of the emerging PM paradigm in an attempt to elucidate the effects of aging on PM performance and to determine if PM is related to executive function.

As indicated by the results, the present study does not support the hypothesis that older adults exhibit overall lower performance on PM tasks. The results are actually unexpected and quite interesting (see Figure 2, attached). None of the age differences are significant, yet there seems to be a general trend: younger adults performed better than the older adults on the EE and TD tasks, whereas the older adults exhibited greater percent accuracy than the younger adults on the ED and TE tasks.

The interaction between age group and task type was significant. Any interpretation of these results is problematic, however, due to the small number of participants per PM task (five), yet for these samples, both age groups performed poorest on the TD task (a significant difference in comparison to the ED task). Overall performance was also low on the EE task, whereas for the TE task the percent accuracy was second highest. The EE task does not require internal cuing or redirection of attention; the ED task requires redirection of attention, yet no internal cuing; the TE task requires internal cuing, yet no redirection of attention; and the TD task requires both internal cuing as well as redirection of attention. Not only do time-based tasks require attention switching, but since the participants are really focusing on two tasks, divided attention is also employed. These comparisons suggest that the four tasks require different degrees of attentional demand, and they may involve a different degree of stress. As a purely speculative hypothesis, PM performance may be related directly to the level of arousal and stress induced by increased levels of attentional demand.

When attentional demand induces a certain level of arousal and stress for the individual, it has been found that "performance of a task is usually best when arousal is moderate" (Coon, 1980, p. 293). Future researchers might consider examining whether arousal or stress are related to PM as a result of attentional demand. Similar to the results of Shapiro, et al.'s (in press) study, none of the attentional and executive function measures correlated with PM task performance. However, one difficulty in studying and measuring these processes is that tests of attention are not well developed. Furthermore, they are often confounded with other mental processes (Woodruff-Pak, 1997). The Stroop Task measures stimulus interference, yet it also could be considered to measure attention switching; the WCST measures primarily perseveration and the demands of multiple mental activities, yet could also be considered to measure divided attention; and the immediate recall test does indeed measure working memory, yet it allows for chunking which may have an influence on performance. Without pure measures of attention and working memory, it is difficult to compare PM and attention. Researchers should consider developing pure measures of attention.

PM performance may also not have correlated with these measures of executive function because the level of attentional demand varied per PM task; or, perhaps some other attentional mechanism is related to PM performance. The PM tasks did not correlate individually with any executive function measures, but the number of participants per dimension is too small for any difference to be reliably detected. This may also be a reason no age difference was detected in the number of clock checks. Regardless, the lack of a difference in clock checking suggest that PM may not be related to internal motivation.

In terms of the PM tasks themselves, both age groups performed significantly better on the *event-based, disembedded* task than on the *time-based, disembedded* task. This finding suggests that difficulties arise in a time-based, as opposed to an event-based task for both groups. Since performance of the two groups on the embedded task did not differ significantly, a general conclusion concerning task type cannot be drawn, yet the results of the present study indicate that the relevant distinction in PM performance is time-based (with a higher attentional demand) versus event-based. Failure to obtain a greater effect of age may once again be due to the small number of participants per dimension (10 participants each) or the level of attentional demand As in previous studies, the groups did not differ on the test of RM, nor did the RM scores on the WAIS-R correlate with the PM scores. Yet, the present study does suggest that as the level of attentional demand increases, not only does overall performance decrease, but older adults exhibit poorer performance on the PM tasks than the younger adults. In addition, the significant lower performance of the older adults in comparison to the younger adults on the measures of executive function, implies that a PM deficit may still be frontal and executive in nature.

One potential problem with this study is a difference in familiarity with computers of the participants. Most of the older adults were not familiar with computers and did not appear comfortable using them. The computer skills required by these tests were no more than typewriter skills, yet using the computer may have intimidated the older adults. Nonetheless, perfect performance by the older adults on the EE task suggests that computer use is not a major confounding factor.

Another confounding variable may be other related health problems. Older adults were screened for health and mental problems and several reported circulatory and heart problems, as well as the use of medication. Such problems may influence cognitive functioning, and subsequently their performance on the tasks, yet by means of a one-way ANOVA, the older adults with circulatory and heart problems did not perform significantly different from the other older adults, $F(1,19) = .2198$, $p<.64$.

Even though the results of the present study allow for speculation, too few participants were tested to provide a definite conclusion. Therefore, the study will be continued by testing more older and younger adults to eliminate the obscuring effects of a small sample size. These PM tasks will also be administered to brain injured populations, since illuminating the distinction between the dimensions of these four PM tasks is necessary in discovering the true mechanisms and consequent deficits in the ability to remember an intention.

References

Brandimonte, M., Einstein, G. O., & McDaniel, M. A. (Eds.). (1996). Prospective Memory: Theory and Applications. New Jersey: Lawrence Erlbaum Associates, Inc.

Cockburn, J. (1995). Task interruption in prospective memory: a frontal lobe function? Cortex, 31, 87-97.

Cockburn, J. & Smith P. T. (1994). Anxiety and errors of prospective memory among elderly people. British Journal of Psychology, 85, 273-282.

Coon, D. (1980). Introduction to Psychology. St. Paul: West Publishing Company.

Craik, F. I. M. & Salthouse, T. A. (1986). The Handbook of Aging and Cognition. New Jersey: Lawrence Erlbaum Associates, 1992.

Cytowic, R. E. (1996). The Neurological Side of Neuropsychology. Cambridge: Massachusetts Institute of Technology.

Dobbs, A. R. & Rule, B. G. (1987). Prospective memory and self-reports of memory abilities in older adults. Canadian Journal of Psychology, 41, 209-222.

Einstein, G. O., Holland L. J., McDaniel, M. A., & Guynn, M. J. (1992). Age-related deficits in prospective memory: the influence of task complexity. Psychology and Aging, 7, 471-478.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16(4), 717-726.

Einstein, G. O.,McDaniel, M. A., Richardson, S. L., Guynn, M. J., Cunifer, A. R. (1995). Aging and prospective memory: examining the influences of self-initiated retrieval processes. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21(4), 996-1007.

Golden, C. J. (1978). Stroop Color and Word Test. Wood Dale, IL: Stoelting

Company.

Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G. & Curtiss, G. (1993). Wisconsin Card Sorting Test. Psychological Assessment Resources, Inc.

Kaufman, A. S., & Kaufman, N. L. (1990). Kaufman Brief Intelligence Test. Circle Pines, MN: American Guidance Service, Inc.

Kvavilashvili, L. (1992). Remembering intentions: A critical review of existing experimental paradigms. Applied Cognitive Psychology, 6, 507-524.

Maylor, E. A. (1990). Age and prospective memory. The Quarterly Journal of Experimental Psychology, 42A, 471-493.

Maylor, E. A. (1993). Aging and forgetting in prospective and retrospective memory tasks. Psychology and Aging, 8, 420-428.

Maylor, E. A. (1996) Age-related impairments in an event-based prospective memory task. Psychology and Aging, 11, 74-78.

Neisser, U. (Ed.). (1982). Memory Observed: Remembering in Natural Contexts. New York: W. H. Freeman and Company.

Roberts, R. J. & Pennington, B. F. (1996). An interactive framework for examining prefrontal cognitive processes. Developmental Neuropsychology, 12, 105-126.

Searleman, A., & Herrmann, D. (Eds.). (1994). Memory from a Broader Perspective. New York: McGraw-Hill, Inc.

Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. Brain, 114, 727-741.

Shapiro, J. A., Shapiro, L. R., Alper, J., & Russell, S. J. (in press) Executive Processes in Prospective Remembering.

Shimamura, A. P. (1995). Memory and the prefrontal cortex. Annals of the New York Academy of Science, 769.

Shimamura, A. P., Janowsky, J. S., & Squire, L. R. (1990). Memory for the temporal order of events in patients with frontal lobe lesions and amnesic patients. Neuropsychologia, 28 (8), 803-813.

Wechsler, D. (1981). Weschler Adult Intelligence Scale-Revised. San Antonio, TX: The Psychological Corporation.

Woodruff-Pak, D. S. (1997). The Neuropsychology of Aging. Oxford: Blackwell Publishers.

Table #1

ANOVA table: PM Score Means (and SDs)

	PM Mean Percent Accuracy & SD			
	EE	ED	TE	TD
Older	59.6(28.0)	100(0.0)	93.2(15.2)	52.8(18.1)
Younger	86.4(18.6)	93.2(15.2)	79.8(30.0)	73.0(28.1)

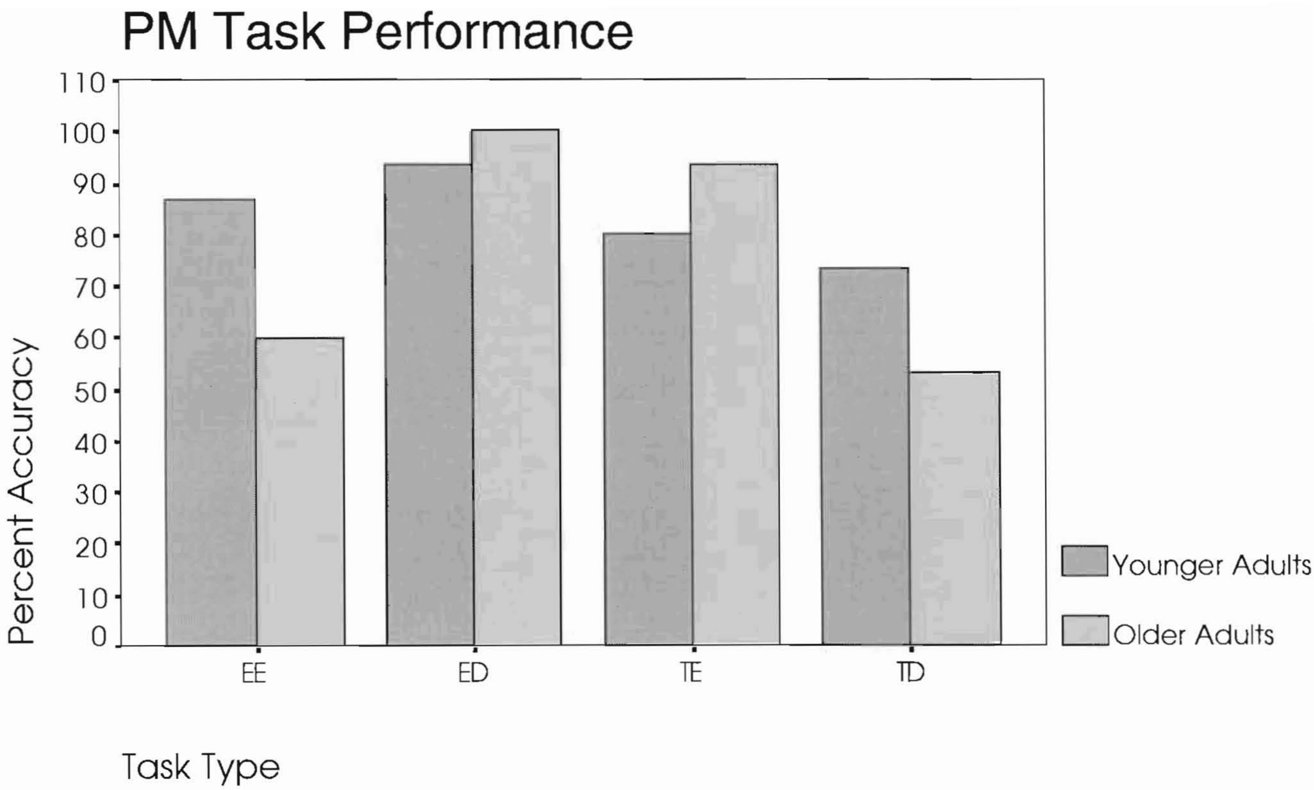
Table #2

Correlational Matrix of PM scores and Cognitive Functioning Measures, Correlation Coefficients and (*p* values) for each PM task

	PM Score			
Cog Measures	EE	ED	TE	TD
Stroop	.50(.14)	.34(.34)	.10(.78)	.13(.74)
WCST	-.26(.47)	.35(.32)	-.31(.94)	-.30(.43)
Immediate Recall	-.33(.35)	.13(.71)	.25(.48)	.07(.85)

Figure Captions

Figure 1. Mean PM task performance as a function of task type, across the variable of age group.


PM Task Performance
Percent Accuracy
110
100
90
80
70
60
50
40
30
20
10
0
EE
ED
TE
TD
Younger Adults
Older Adults
Task Type